WALNUT GULCH EXPERIMENTAL WATERSHED

AGRICULTURAL RESEARCH SERVICE
UNITED STATES DEPARTMENT OF AGRICULTURE

Cooperating With The

AGRICULTURAL EXPERIMENT STATION
UNIVERSITY OF ARIZONA

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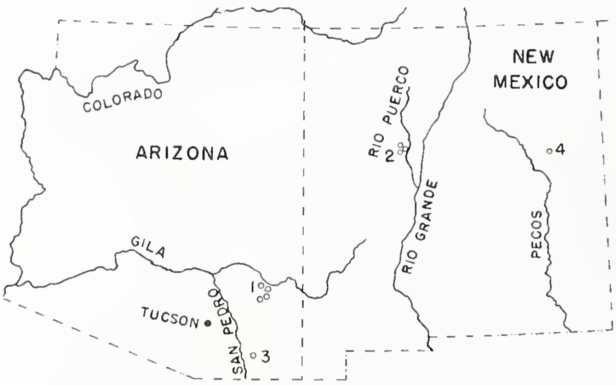
SOUTHWEST WATERSHED RESEARCH STATION

The studies on the Walnut Gulch watershed at Tombstone, Arizona are part of the comprehensive research begun in 1951 by the Research Division of the Soil Conservation Service at the request of the Operations Division of that Service. Their request was for information concerning the relation of practical range conservation measures to production of sediment and yield of useable water from semiarid rangeland watersheds of the Southwest.

After considerable screening of prospective areas in Arizona, New Mexico, and Colorado, active research was begun in 1953 on the Walnut Gulch area, and in 1954 on the Alamogordo Creek area near Santa Rosa, New Mexico. In 1954, the research and personnel were transferred to the Agricultural Research Service; and in 1961, the Southwest Watershed Research Station was established with headquarters at Tucson. The research is being carried on in cooperation with the Agricultural Experiment Stations of Arizona and New Mexico, the Soil Conservation Service, the local Soil Conservation Districts, and the ranchers who own the land of the watersheds. Less extensive work is being done on several small drainage areas near Safford, Arizona, and Albuquerque, New Mexico, where runoff and precipitation data have been collected since 1939.



1. SAFFORD, ARIZONA
2. ALBUQUERQUE, NEW MEXICO
3. WALNUT GULCH nr. TOMBSTONE, ARIZONA
4. ALAMOGORDO CREEK, near SANTA ROSA, NEW MEXICO

FIGURE: Location of Experimental Watersheds

The research objectives are being approached by two avenues: one aimed at isolation and analysis of factors affecting water yield, sediment movement, and storm runoff, followed by integration of the findings as they apply to unit source areas and complex watersheds; the other, at making observations of water yield, sediment movement, and storm runoff from untreated complex watersheds during a calibration period representative of the climate, followed by a similar period during which a range conservation program will be applied to all or parts of the watershed and the same observations continued. Length of this calibration period has not been determined; but it is clear that it must be sufficient to afford a reasonable sampling of the effective factors. The two methods of approach are being pursued simultaneously.

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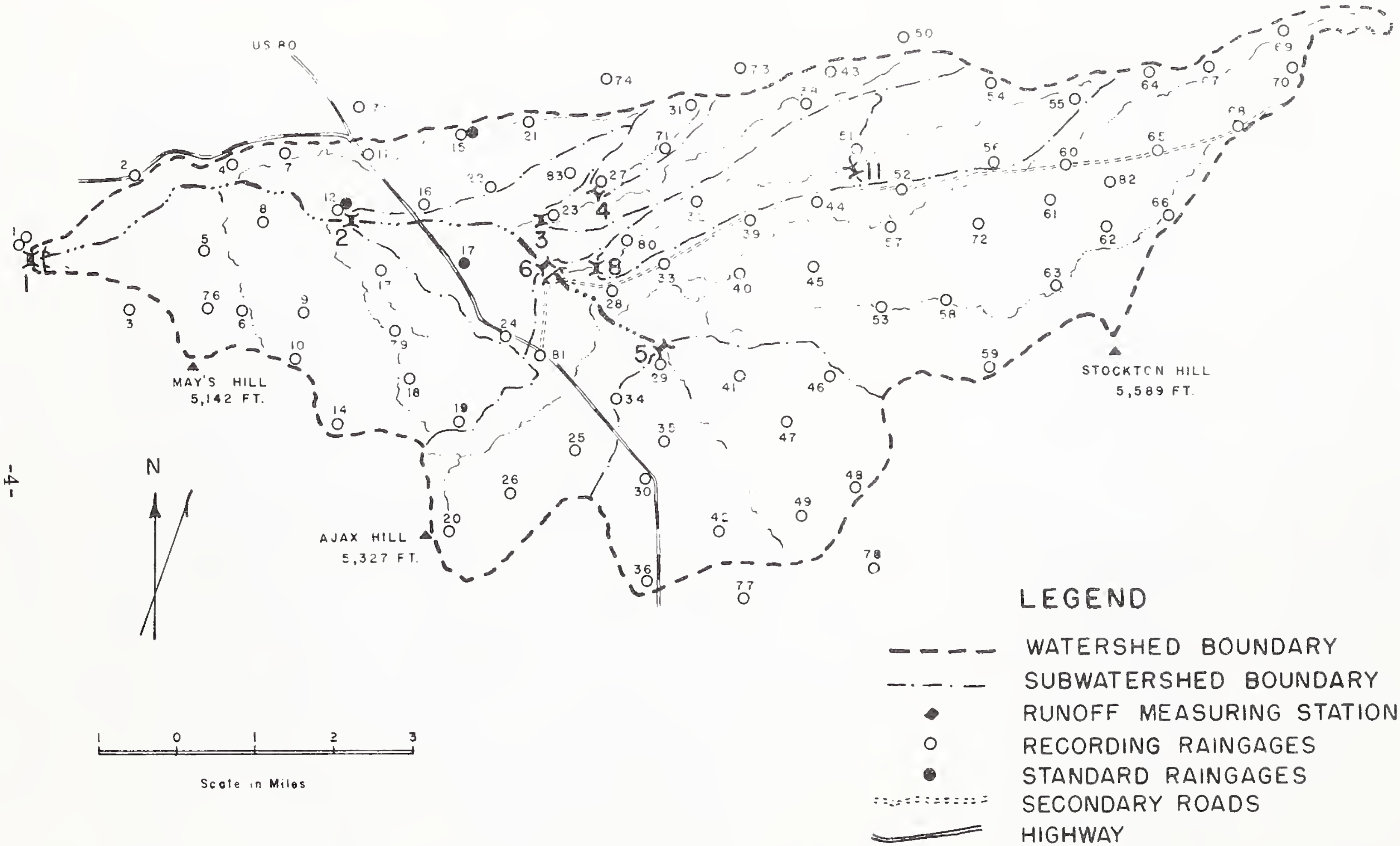
WALNUT GULCH EXPERIMENTAL WATERSHED

Walnut Gulch enters the San Pedro river at Fairbank, Arizona. The study area comprises the upper 58 square miles of the drainage basin. There is evidence that much of the area was grassland less than 75 years ago; but now the vegetation on about two-thirds of it is predominantly shrubs--mainly creosotebush, tarbush, mortonia, and whitethorn--among which are varying amounts of the original grasses. The remaining third is still grassland. It is dominated mainly by black grama, curly mesquite grass, and tobosa grass.

Walnut Gulch Watershed. The Dragoon Mountains are in the background and the city of Tombstone in the foreground. Extreme upper end of watershed lies below gap in mountains at right.

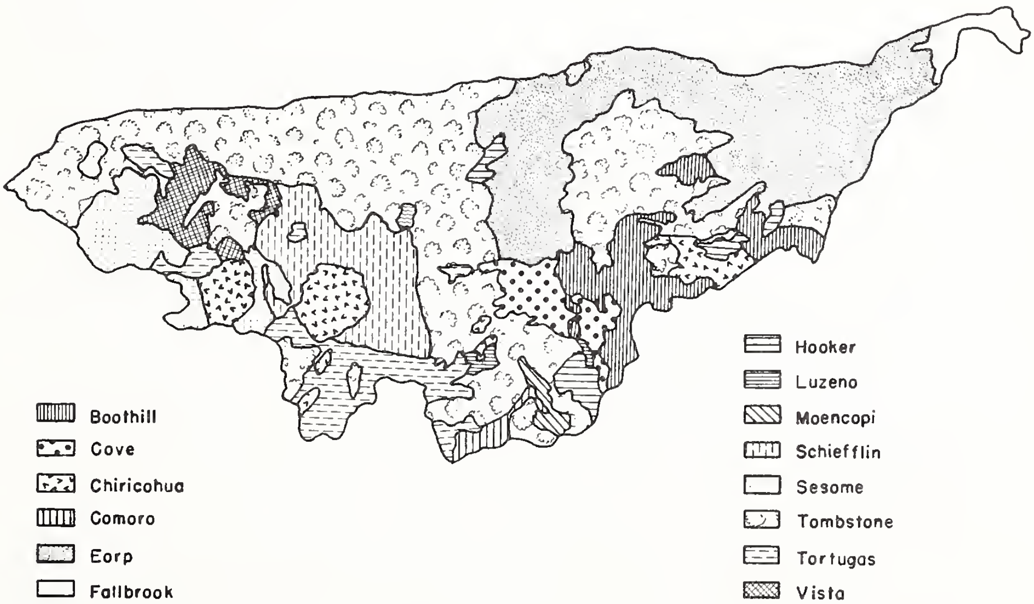


DRAINAGE MAP
SHOWING
HYDROLOGIC MEASURING INSTALLATIONS

VEGETATION AND SOILS

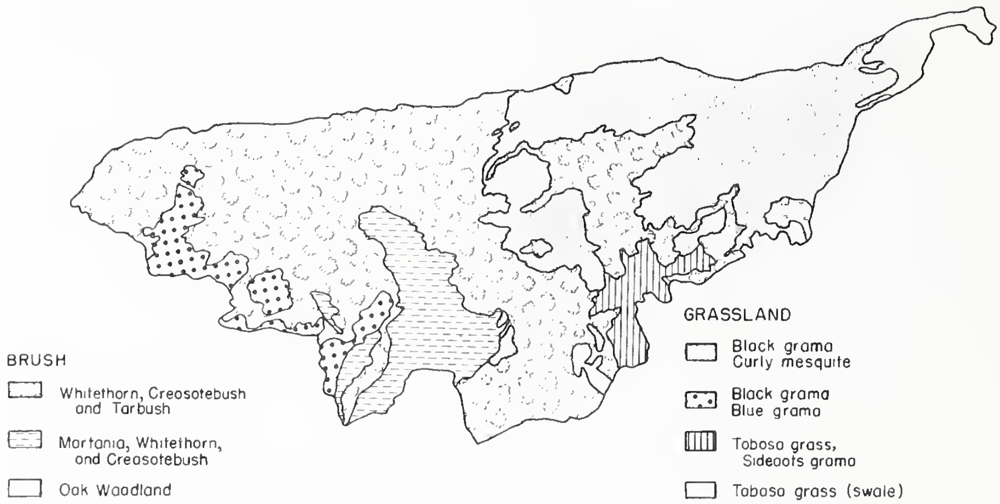
Vegetation and Soils

The vegetation and soils of the area have been surveyed and mapped in detail. Of the fourteen soil units delineated, some bear recognized names; the names of others--such as Boothill (which, ironically, does not include the famous Boot Hill Cemetery), Earp, and Tombstone--are tentative. These fourteen soils were developed on ten parent geologic materials. Although cover of grasses and shrubs, as well as that of individual species, is correlated in varying degree with soils and some of their physical and chemical characteristics, distribution of but one major species--mortonia--is sharply limited by soil. The most striking correlation of plant cover is with distance from the town of Tombstone: as this distance increases total grass cover increases and total shrub cover decreases. This lends credence to the hypothesis that grass cover has diminished and shrub cover has increased since settlement of the town about 1880.



SOILS MAP

Work is in progress to investigate the relation of soils and components of the vegetation to runoff and sediment production from unit source areas on the watershed and on the watershed as a whole.



VEGETATION MAP

Here, in 1905, according to one of the early ranchers, there was not "a bush big enough for a calf to hide behind".

Good grassland. The grasses are mainly black grama and side-oats grama. The shrub by the man is Spanish bayonet.

GEOLOGY

The valley fill upon which the watershed lies is covered by a layer of coarse-grained Late Pleistocene sediments--the Tombstone Terrace--which varies in depth from 0 to nearly 100 feet. This layer is separated from the underlying, fine-grained, Early to Middle Pleistocene sediments of the major valley fill by a deposit of calcium carbonate. From drilling operations, it appears that depth of the Tombstone Terrace sediments near Flume 1 at the main outlet of the watershed is about 35 feet.

The fine-textured sediments of the major valley fill were deposited in swamps, lakes, and slow-moving streams under a cool, humid climate. Such deposits profoundly affect flow of subsurface water under the watershed. These strata are exposed in the badlands lying north of the experimental area. Heavy mineral and X-ray studies indicate that the rocks from which these sediments came were of granitic, limestone, and schistose origin, with the granites predominating.

Badlands north of the experimental area, showing stratification of the major valley fill.

PRECIPITATION

Annual precipitation since 1897 at Tombstone has averaged 14.26 inches. The amount recorded for different years has varied from 7.36 inches in 1924 to 27.84 inches in 1905. Similar though less pronounced variation has been observed in a single year among the network of 85 recording gages we are maintaining on the watershed. The year's precipitation falls during two distinct periods, with greatly differing characteristics. Winter precipitation, amounting to 30 percent of the annual, occurs as snow or rain of wide extent and low intensity. We have never recorded runoff from winter storms. Most of the remaining 70 percent of the precipitation falls during July, August and September as intense convective thunderstorms of small diameter. Practically all runoff results from this type of storm. Eighty percent of these summer thunderstorms have been observed to cover only small areas of 4.5 square miles or less.

Since small, intense storms of this sort have important effects on the runoff pattern of the watershed, adequate records of their distribution, amount and intensity are indispensable; hence the dense network of 85 recording gages on or just off of the 58-square-mile area.

Radar equipment is used to observe the location and movement of small thunderstorms while they are occurring. Two-way radio contact between headquarters, where the radar set is located, and observers in the field helps to get crews to the right spot at the right time to get the desired samples and measurements during flows. In addition, radar pictures of the storm events supplement the records from the rain gage network.

A typical runoff-producing summer thunderstorm. Only a small fraction of watershed area is covered.

Isohyetal map shows rainfall distribution on the watershed for a typical summer thunderstorm. Runoff-producing rainfall covered about 3 square miles.

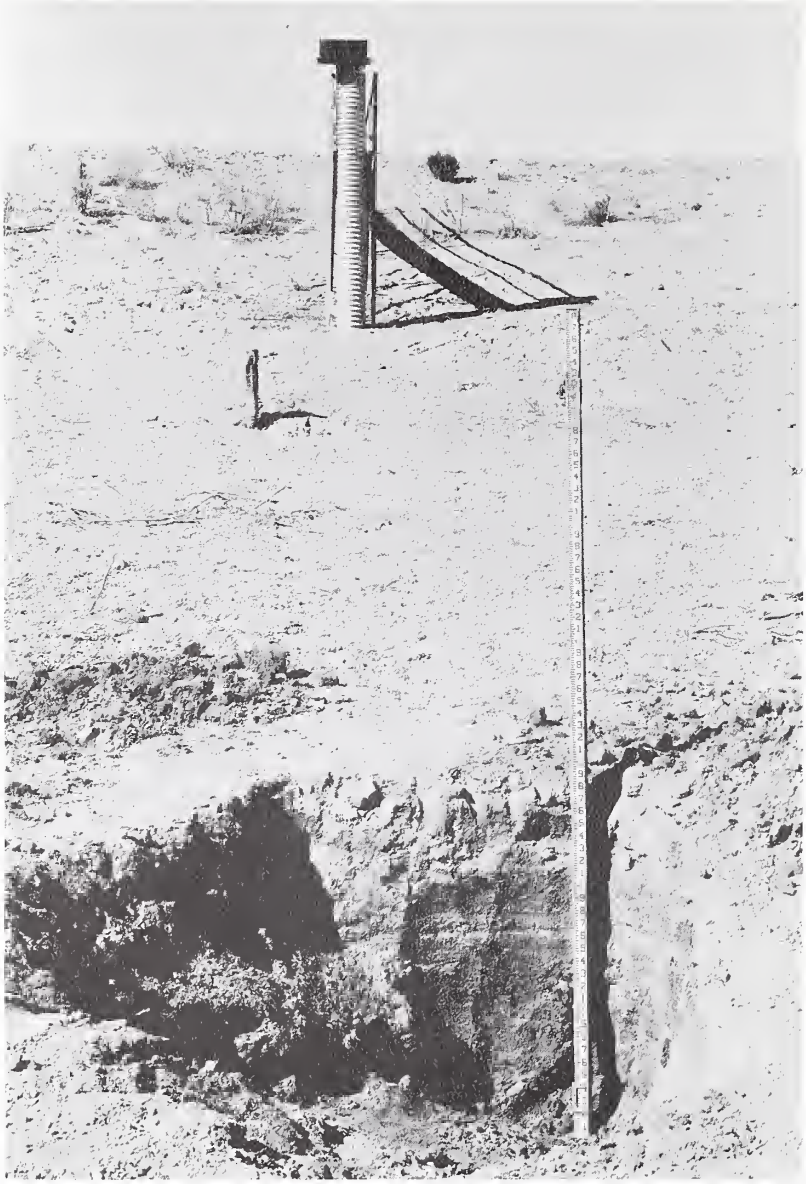
UNIT SOURCE DRAINAGE AREAS

Because of the small diameter of the runoff-producing storms and the differences in soils and vegetation prevailing over the watershed, subwatersheds of from 3 to 375 acres with relatively homogeneous soil and vegetation have been selected for study of runoff and sediment yield. Five of these areas, varying from 3 to 11 acres, are equipped with V-notch weirs for measuring runoff. Five others, ranging from 18 to 375 acres, drain into stock ponds, where the runoff and sediment are measured. Four of the smaller areas lie within or adjacent to one of the stock pond drainage areas, which is brush-covered. After a suitable calibration period, two of these small areas will be subjected to range treatment--seeding, brush removal, etc.--and the other two will be left untreated as a check.

The drainage areas above the stock ponds differ markedly in soils and vegetational cover, and thus afford valuable comparisons. Bennett's Big Tank, for example, built in 1938, catches water from 375 acres of grassland. Its bed, covered with a layer of fine sediment, is relatively impermeable, and the tank usually holds water throughout the year. On the other hand, Lucky Hills Tank, built in 1956, receives water from 117 acres covered mainly with creosotebush, tarbush, and white thorn. Its bed is of highly calcareous soil and is very permeable. In Agust 1960, this pond lost three acre-feet of water in 9 days. In cooperation with the U. S. Water Conservation Laboratory at Tempe, field trials of monomolecular films and bed-sealing methods are under way to reduce evaporation and seepage losses.

Sediment production, as indicated by accumulation in the ponds, is considerably greater from brush-covered areas than from those covered with grass. This is probably attributable to two factors: shrub invasion has been greater on the less stable soils, and grass protects the soil surface better than do shrubs. During a four-year period, sediment loss per acre was almost four times as great from the brush-covered Lucky Hills area as it was from the grass-covered Bennett area.

Bennett's Big Tank, which was nearly filled in July, still has adequate supply of stock water the following March.



Lucky Hills Tank, although full in late August, was completely dry by mid-November. Its brush-covered drainage area has yielded nearly 4 times as much sediment as the grass-covered area above the Bennett Big Tank.

ON-SITE RUNOFF

Relation of on-site runoff and sediment production to characteristics of soils and vegetation is under study on 6x12-foot plots receiving different treatments or no treatment. The treatments include brush removal, soil pitting and reseeding to grass--alone and in combination--on one set of plots. Those of another set receive fertilizer and are sprinkled to alter soil moisture.

For all the plots, records of soil moisture, rainfall, and runoff are kept; and the amounts of runoff and sediment from the plots receiving the different treatments are compared.

Results of infiltrometer studies on these and similar plots indicate that runoff decreases with an increase in crown spread of vegetation, amount of pebbles on the soil surface, and number of plants per plot. Thus far the data are insufficient to show the relation of runoff to plot treatment or to antecedent soil moisture.

Under the semiarid conditions prevailing on the watershed, runoff per unit area on small plots of this sort is greater than that from larger areas; but such plots should furnish information concerning the relation of runoff and sediment production to plant and soil factors and to range treatments on larger areas. As the information accumulates, attempts will be made to extend it to successively larger adjacent areas and, in conjunction with soil and vegetation surveys, to the entire 58-square-mile watershed.

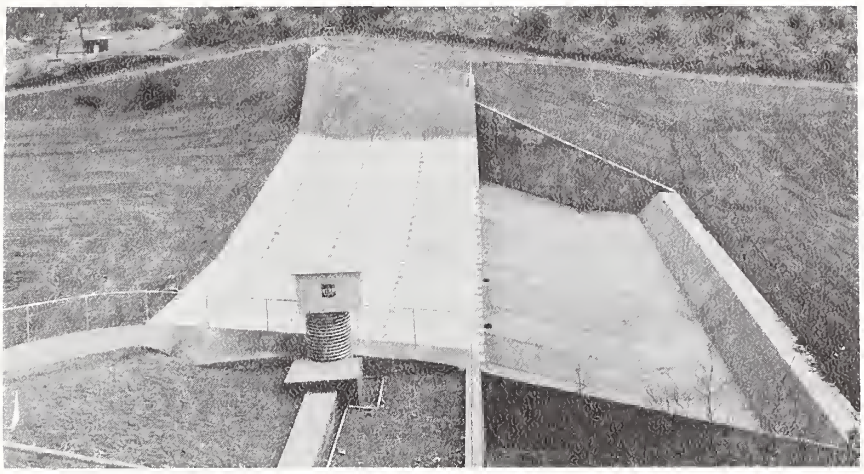
FLOW MEASUREMENTS

In addition to the measurements being made on the unit source areas, streamflow is gaged at eight gaging stations--five on tributaries and three on the main channel of Walnut Gulch. The measuring structures at these stations are prerated, critical depth flumes. They were developed cooperatively by staff members of the Southwest Watershed Research Station and the Agricultural Research Service Hydraulics Laboratory at Stillwater, Oklahoma, to obtain accurate measurement of the sediment-laden flows of ephemeral streams. Of the three flumes in the main channel, Flume Number 1, with a capacity of 22,500 cubic feet per second, measures the runoff from the entire 58 square miles; Flume Number 2, with a capacity of 18,500 cubic feet per second, subtends a drainage area of 44 square miles; and Flume Number 6, below an area of 37 square miles, has a capacity of 14,000 cubic feet per second. Flume Number 1 is probably the largest prerated critical depth flume in the United States.

A flow of 2,000 cu. ft. per second in Flume 6, which has a capacity of 14,000 cu. ft. per second and measures runoff from 37 square miles. The men in the cable car are taking sediment samples.

5:23 p. m. Runoff water entering Flume Number 2 from thunderstorm occurring 10 miles upstream 2 hours earlier.

5:30 p. m. Seven minutes later, flash flow has reached peak of 850 cubic feet per second.

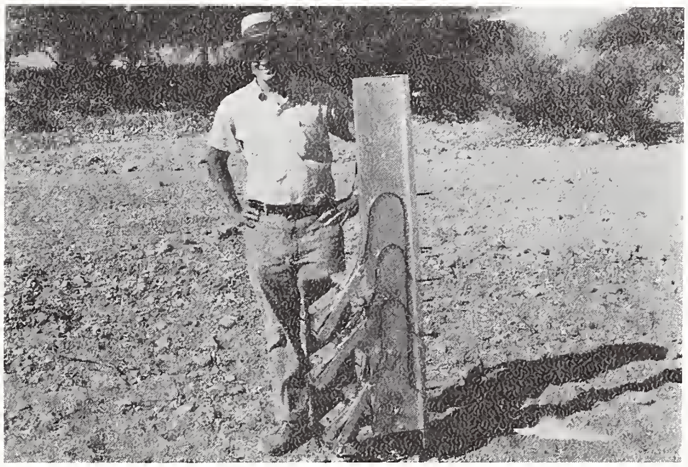


Flume Number 1 from north bank, showing stilling basin. Because of the unstable substructure, this stilling basin was required to prevent scour damage to the flume during high flows.

SEDIMENT STUDIES

The processes of sediment production, transport, and deposition in ephemeral stream channels are being studied at several places on the watershed. Sediment samples are collected from 6x12-foot plots, from unit source areas of varying size, and in the larger channels. From higher flows in the channels, they are collected from cableways; from low flows, by wading. At several places in the channels, also, samples are taken by automatic, single-stage samplers. Heavy mineral studies are being made to get information on sources of the sediment.

The information furnished by these samples should enable us to relate on-site sediment production and movement to that from progressively larger areas and to extend these relationships as they are affected by characteristics of climate, topography, geology, and vegetation to sediment yield and transport on semiarid watersheds.

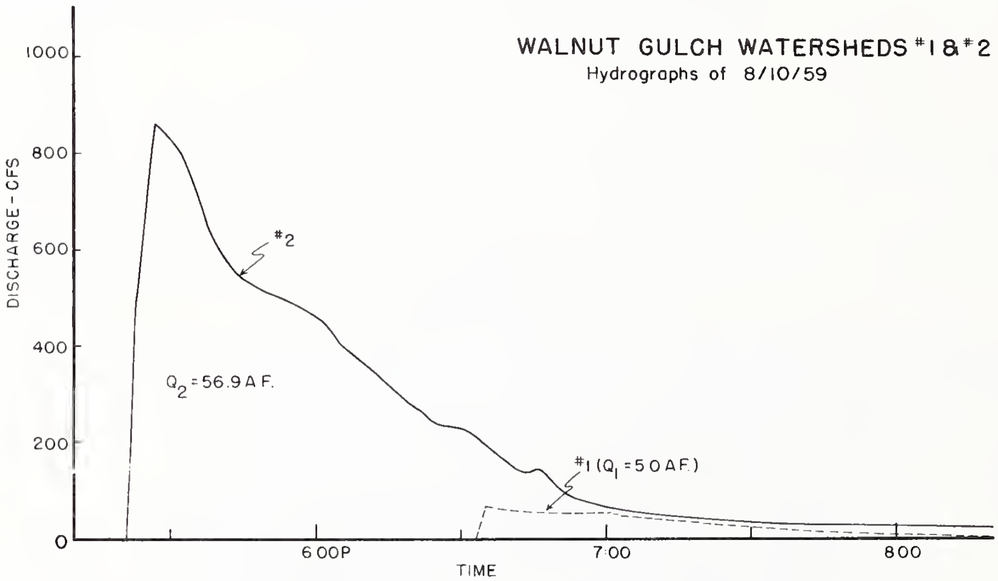


Automatic sediment sampler. As the flow rises, each bottle collects a sample at a fixed elevation. Flow into the bottle automatically ceases when the bottle is full.

GROUND WATER

Ground water levels of the watershed vary greatly--from 150 feet at the lower end to more than 425 feet in the central areas. Small local water tables, perched at depths of 10 to 35 feet, occur in a few places along the channel system of Walnut Gulch.

Recent studies indicate very little recharge to groundwater from the upper reaches of the watershed. In the lower reaches, however, channel absorption may contribute to the regional water table. Owing to the small diameter of the runoff-producing storms, much of the channel which the runoff traverses is usually dry and absorbent. Between Flumes Number 1 and Number 2, this absorption has amounted to as much as 18 acre-feet per mile of channel during a moderate sized flow; and, owing to the much greater width of channel covered, much higher absorption per mile of channel may be expected from higher flows. In some situations, subsurface flow occurs in the coarse channel materials.



Nearly the entire volume of flow passing Flume Number 2 was absorbed in the 4-mile reach of channel between Flume 2 and the watershed outlet. Transmission loss for this event was 12 acre feet per mile.

When geologic conditions are favorable and the channel bed is saturated from previous flows, some of the water absorbed from storm flows percolates downward and causes a mounding of the underlying regional water table. This condition typically occurs in the latter part of the summer toward the end of the flow season and continues for about two months. Then the mounding is gradually dissipated, and the regional water table levels out. With continued study of this mounding effect, we may find that it contributes significantly to the regional ground water and is important in the overall water balance of the watershed.

The small local aquifers mentioned above owe their existence to impervious material underlying the channel. The quick response of the water level in nearby wells to flows in the channel leads us to conclude that at least a part of the water absorbed by the channel contributes to these local aquifers. Water level records from these wells show that the drop in the water level is four times as great during the growing season as it is when the vegetation is dormant, indicating that a considerable proportion of the water entrapped in these local aquifers is dissipated by evapotranspiration of phreatophytes. Intensive research is underway on one of these local areas to determine what happens to the entrapped water; i. e., how much is removed by plants, how much is dissipated by direct evaporation, and whether any reaches the regional water table.

Dense mesquite growth defines limits of local aquifer lying beneath the stream channel. Transmission loss water is stored in the aquifer, and much of it is removed by the vegetation during the growth season.

The basic information collected in the various phases of the work of the Southwest Watershed Research Station should contribute to more comprehensive understanding of interacting factors affecting land use, sediment production and movement, and water yield, and to an intelligent synthesis of these factors as they affect the use of vast areas of semiarid rangeland in the Southwestern United States.

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